NATIONAL HIGH MAGNETIC FIELD LABORATORY

NHMFL

FLORIDA STATE UNIVERSITY

SAFETY PROCEDURE

SP-21

LASER SAFETY PROCEDURE

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TITLE: LASER SAFETY PROCEDURE

1.0 PURPOSE

1.1 This procedure establishes policy to be observed by all personnel at the NHMFL when operating lasers or laser systems during experimentation and research.

1.2 The policy of the NHMFL is to provide and maintain a safe and healthful working environment. Employees and users alike shall assist in ensuring that safety is not compromised. The safety and health of employees and users is the inherent responsibility of each employee, user, management, and all levels of supervision.

2.0 SCOPE

This document assigns responsibilities, provides safety guidance, and defines actions to be taken to protect workers from the hazards involved with the use of lasers and laser systems.

3.0 DEFINITIONS:

ANSI (American National Standard Institute) has recently adopted the (IEC) International Electrotechnical Commission laser classification. Both the old and new classification are shown in the definitions below as most lasers at the NHMFL are classified based on the old classification system.

3.1 *Class 1*: A laser or laser system containing a laser, that under normal operating conditions, does not pose a hazard. The new classification system includes **Class 1M lasers** which are high powered lasers that have been modified to meet the class 1 standards. Class 1M have wavelengths between 302.5 nm and 4000 nm, and are safe except when used with optical aids (e.g. binoculars).

3.2 *Class 2*: Visible light lasers (400-700 nm). Class 2 lasers are safe because the eye aversion response will limit the exposure to no more than .25 seconds. Class 2 lasers are limited to 1mW continuous wave or more if the

emission time is less than .25 seconds or if the light is not spatially coherent.

3.3 **Class 2M lasers** as lasers having wavelengths between 400 nm and 700 nm, and are potentially hazardous when viewed with an optical instrument.

3.4 *Class3R*: A medium power laser or laser system which is capable of exceeding maximum permissible exposure (MPE) levels for the eye within .25 s but still pose a low risk of injury. Lasers in this class are mostly dangerous in combination with optical instruments which change the beam diameter or power density. Output power does not exceed 5mW. Beam power density may not exceed 2.5 mW/square cm

3.5 *Class3B*: A medium power laser or laser system with power levels of 5 mW to 500 mW for continuous wave lasers or less than 10 J/cm² for a 0.25 s pulsed laser. These lasers will produce an eye hazard if viewed directly. This includes intrabeam viewing or specular reflections. Higher power lasers in this class will also produce hazardous diffuse reflections. Class 3B lasers can cause permanent eye damage with exposures of $1/100^{th}$ of a second or less depending on the strength of the laser.

3.6 *Class4*: Includes ultraviolet (0.18 to 0.4 um) and infrared (1.4 um to 1 mm) lasers and laser systems which (a) emit an average accessible radiant power in excess of 0.5 W for periods $\geq$ 0.25 s or (b) produce a radiant energy greater than 0.125 J within an exposure time of < 0.25 s. Also, visible (0.4 to 0.7 um) and near-infrared (0.7 to 1.4 um) lasers and laser systems which (a) emit an average accessible radiant power of 0.5 W or greater for periods $\geq$ 0.25 s or (b) produce radiant energy in excess of $0.03C_A$ J. Lasers in this class have output powers of more than 500mW in the beam and may cause severe, permanent damage to eye or skin without being magnified by optics of eye or instrumentation. Diffuse reflection of the laser beam can be hazardous to skin or eye within the Nominal Hazard Zone.

3.7 *Controlled Area*: An area where the occupancy and activity of those within is subject to control and supervision for the purpose of protection from radiation hazards.

3.8 *Control Disconnect*: Any device which will turn off the laser or terminate the beam. The laser power supply can serve as a control disconnect if it is located outside the controlled area.

3.9 *Facility*: Any location where one or more lasers or laser systems are used or operated.

3.10 *Incident*: An event or occurrence which results in real or suspected accidental exposure to laser radiation that caused or is likely to cause biological damage.

3.11 *Ionizing Radiation*: Electromagnetic radiation having a sufficiently large photon energy to directly ionize atomic or molecular systems with a single quantum event.

3.12 *Laser*: A device which produces an intense, coherent, directional beam of light by stimulating electronic or molecular transitions to lower energy levels. An acronym for Light Amplification by Stimulated Emission of Radiation.

3.13 *Laser Personnel*: Any person who actively engages in the operations of a laser or laser system, including the installation, aligning, and firing of a laser or laser system.

3.14 *Laser Safety Officer (LSO*): One who has authority to monitor and enforce the control of laser hazards and effect the knowledgeable evaluation and control of laser hazards. The NHMFL Assistant Director of Environmental, Health, Safety and Security shall serve as the Laser Safety Officer for the NHMFL and shall work with the FSU LSO to fulfill the LSO responsibilities for the NHMFL.

3.15 Lab Laser Safety Officer (LLSO): The Principal Investigator or his/her designee will serve as LLSO for the laser lab under their supervision.

3.16 *Laser System*: An assembly of electrical, mechanical, and optical components which includes a laser.

3.17 *Maximum Permissible Exposure (MPE*): The level of laser radiation to which a person may be exposed to without hazardous effects or adverse biological changes in the eye or skin.

3.18 *Power*: The rate at which energy is emitted, transferred, or received. Unit: watts (joules per second).

3.19 *Protective Housing*: An enclosure that surrounds the laser or laser system that prevents access to laser radiation above the applicable MPE level. The aperture through which the useful beam is emitted is not part of the protective housing.

3.20 *Spectator*: An individual who wishes to observe or watch a laser or laser system in operation, and who may lack the appropriate laser safety training.

3.21 *Wavelength*: The distance between two successive points on a periodic wave which have the same phase.

3.22 *Diffuse Reflection:* Change of the spatial distribution of a beam of radiation when it is reflected in many directions by a surface or by a medium.

3.23 *Specular Reflection:* A mirror like reflection.

3.24 *Intrabeam Viewing:* The viewing condition whereby the eye is exposed to all or part of a laser beam.

3.0 RESPONSIBILITIES

3.1 The Principal Investigator (PI) is responsible for the safe use of lasers in the PI's laboratory. The PI must notify the Safety Office upon purchasing a class 3 or 4 laser device. The PI must notify the Safety Office of any changes in the operational status, such as location changes and or modifications to any laser equipment that may change the classification number. The PI may assign each laser facility a Laboratory Laser Safety Officer (LLSO), who has the proper training and background to perform this function or the PI will be the default LLSO. The LLSO is responsible for:

- Coordinating with the Safety Department to ensuring the proper registration of all class 3B & 4 lasers and personnel who will operate the lasers.

- Ensuring that all personnel that work in their area have completed the Basic Laser Safety Training.

- Developing, maintaining, and updating, as needed, all operating, alignment, and emergency procedures (SOP's) for the lasers and facility under the LLSO's control.

- Acting as the contact for the Safety Department.

- Enforcing the safety standards defined in the NHMFL Laser Safety policy in their area.

- Supervising all spectators, visitors and personnel with access to their facility to ensure against unauthorized entrance or accidental exposure to laser radiation.

- Updating all records to reflect changes in personnel or equipment by contacting the Safety Department.

- Reporting all incidents involving safety violations or injury to the Safety Department at 855-SAFEMAG (723-3624).

- Ensuring that all personal protective equipment in the laser area is properly maintained.

- Ensuring that everyone that each laser user in the laser area has complete online training and on the job training (OJT).

3.2 The individual user (laser operator) shall observe all safety precautions and operating procedures while using lasers and shall inform the PI, LLSO and NHMFL Safety Department of any apparent safety problems associated with the use of the laser. Each laser operator shall be adequately trained as defined in this procedure. The laser operator shall be responsible for:

- Following laboratory administrative, alignment, and SOP's while operating lasers and reading safety instructions in laser equipment operator's manuals.

- Keeping the PI fully informed of any departure from established safety procedures. This includes notification of an exposure incident.

- Taking the NHMFL online Laser Safety Training Course and completing laser on the job training (OJT)

3.3 The Florida State University's Environmental Health and Safety Office has designated a University Laser Safety Officer (LSO) to coordinate compliance efforts with chapter 64E-4, FAC. The NHMFL Assistant Director of Environmental, Health, Safety and Security shall serve as the Laser Safety Officer for the NHMFL and shall work with the FSU LSO to fulfill the LSO responsibilities for the NHMFL. The NHMFL LSO has jurisdiction over all aspects of hazard prevention and control of laser radiation at the NHMFL and has the authority to suspend any operation that constitutes a radiation health hazard to the equipment operators, NHMFL personnel, or the general public. The NHMFL LSO in conjunction with the University LSO will have the following responsibilities at the NHMFL:

- Conduct annual lab inspections to ensure that safety requirements are followed.
- Review and submit all laser SOP's to the Laser Safety Committee for review.
- Authorize laser lab use areas.
- Provide assistance in evaluating and controlling hazards.
- Update the Laser Safety Procedure when necessary.
- Maintain training records.
- Ensure the provision of laser safety training for personnel who are assigned to an area where lasers are operated.
- Participate in accident investigations involving lasers.
- Coordinate semi-annual Laser Safety Committee (LSC) meetings.

4.0 REGISTRATION

4.1 All class 3B and 4 lasers shall be properly registered with the ***FSU*** Radiation Safety Office. The NHMFL LSO will assist with the registration process.

4.2 All newly registered lasers and facilities must be inspected and approved for operation by the NHMFL LSO prior to beginning laser operations.

5.0 PERSONAL PROTECTIVE EQUIPMENT

5.1 Enclosure of the laser equipment or beam path is the preferred method of control, since the enclosure will isolate or minimize the hazard. Personal protective equipment is necessary when these control measures do not provide adequate protection from the direct or reflected beams.

5.2 Protective eyewear designed for the specific laser being used must be worn by all individuals having access to Class 3B & 4 laser controlled areas during startups, tests, alignments, and operations. The selection of the eyewear shall be based on the power of the laser or laser system, wavelengths and optical density. The PI or LLSO who operates or supervises the operation of a laser is responsible for determining the need for laser eye protection for a particular laser and ensuring that personnel in the area wear the appropriate eyewear when needed. If required, eye protection shall be provided for staff and visitors to the area. The LSO can provide assistance in eyewear selection. Periodic cleaning and inspection shall be made of protective eyewear to ensure the maintenance of satisfactory condition. Damaged eyewear shall be discarded and replaced. Protective eyewear shall be stored so as to prevent damage to the lenses and frames. Avoid storing in direct sunlight and protect from chemical exposures. Refer to the manufacturer's recommendations for proper cleaning techniques.

5.3 Respiratory protection, including dust masks and air purifying respirators, may be necessary if engineering controls, such as ventilation equipment, do not reduce airborne contaminants below acceptable levels.

6.0 SAFETY TRAINING

The NHMFL LSO will develop and administer the safety training programs for all personnel using Class 3B & class 4 lasers or laser systems at the NHMFL and incidental personnel not at risk of exposures to laser radiation. Personnel that work with lasers shall receive training prior to the assignment to work with lasers or laser systems. A refresher training program shall be offered every 2 years. The laser training program is offered on line and emphasizes the general safety aspects of laser use, including safe work practices, engineering controls, personal protective equipment, and accident reporting. Some labs have areas specific laser training online. The PI, LLSO or designee shall provide documented on the job laser training on the safety use and operation of lasers in their area. Incidental personnel at limited risk to an exposure may receive training on awareness and avoidance of areas containing lasers or laser system.

The LSO shall take specialized Laser Safety Officer training.

7.0 MAINTENANCE

Maintenance and service of lasers and laser systems shall be performed by authorized maintenance personnel for all classes of lasers. Principal Investigator or his/her designee shall be responsible for arranging for maintenance and service.

8.0 POSTING LASER USE AREA

All laser use areas containing Class 3B or Class 4 lasers shall be posted with the appropriate signs, per ANSI Z136.1 or Z136.8. Class 1 and Class 2 laser facilities are not required to be posted.

9.0 GENERAL SAFETY RULES

The general rules below must be followed by all laser personnel, visitors, users and spectators to ensure maximum safety.

9.1 Education and training shall be provided for all laser personnel prior to assignment to working with a laser or laser system.

9.2 A Temporary Work Authorization (Appendix 1) form must be completed and signed by the PI, LLSO and LSO prior to performing laser work in any non-approved laser area for a temporary period of time.

9.2 Lasers should be operated in well lighted areas when possible. If not possible, safety measures shall be taken to ensure the safety of the personnel in the area. This may include the use of glowing light switches, flashlights, and lighted exit signs to facilitate evacuation in the event of an emergency.

9.3 Only persons authorized by the LLSO shall perform alignment operations. Visual alignment shall be done with appropriate laser alignment goggles or the laser should be powered down to the lowest practical level during alignment. If unable to power down the laser or laser system, appropriate control measures and personal protective equipment shall be utilized. During alignment, the primary beam, or a specular or diffuse reflection of a beam, shall not expose the eye to a level above the MPE.

9.4 Do not look directly into a laser beam at any time.

9.5 Ensure that all beams and reflections are kept with the boundary of the laser table.

9.6 Flash lamps used with solid state lasers should be shielded.

9.7 Utilize beam shutters or caps when laser transmission is not required.

9.8 Servicing of lasers and laser systems must be performed by qualified staff only.

10.0 CLASS 3B & CLASS 4 LASER REQUIREMENTS

Each laser and laser facility must be designed to ensure that maximum protection is afforded to the operator. Control measures shall be devised and taken to ensure minimal exposure to the eyes and skin from hazardous laser radiation.

Class 3B Lasers

- Never aim a laser at a person's eye.
- Use proper laser eyewear if there is a chance that the beam or a hazardous specular reflection will expose the eyes.
- Avoid placement of unprotected eye along or near the beam axis.
- Assure that individual do not look directly into a laser bear with optical instruments without adequate protective filters.
- Eliminate unnecessary specular (mirror-like) surfaces from the vicinity of the laser beam path or avoid aiming at such surfaces.
- Do not aim the beam at doorways or windows.

Class 4 Lasers

In addition to the Class 3B requirements Class 4 laser facilities should meet the following criteria:

- Each area must be under the direct supervision of the LLSO.
- Access to the area must be supervised. The entrance to the doors must be closed at all times. There should be a barrier between the door and laser area.
- The area must have appropriate signs posted.
- Jewelry shall not be worn while operating lasers.
- All potentially hazardous beams in the area must be terminated in an appropriate beam stop.
- All optical paths that can allow the beam to exit the control area must be covered or restricted in a manner that prevents transmission of laser radiation.
- If a beam is to exit the controlled area, the LLSO shall ensure the beam path is limited to controlled air space.

- Protective eyewear designed for the specific laser being used must be worn by all individuals having access to Class 3B or Class 4 laser radiation during operation.
- Since viewing portals and collecting optics may increase the hazards, all devices must incorporate a means to maintain laser radiation emitted through them at or below safe levels. The Laboratory LSO shall determine the potential hazard and take proper safety measures.
- Beam stops or attenuators must be permanently attached and capable of preventing output emission when the laser is on standby.
- If at all possible, the interaction area, that is the area where the primary beam or secondary beam irradiates the sample material, should be enclosed and equipped with a safety interlock so that the laser cannot be operated unless the interlock is in place.
- If possible, Class 4 lasers with exposed beam paths should be fired remotely.
- If any engineering controls listed above cannot be accomplished, or will impede the nature of the research, administrative controls should be formulated by the PI and submitted to the LSO for approval. These administrative controls shall be part of a SOP or Temporary Work Area controls.

11.0 ELECTRICAL HAZARDS

Electrical shock hazards can occur from contact with exposed utility power utilization, device control, and power supply conductors. These hazards can occur during laser set up, installation, maintenance, service, or where protective covers are removed to allow access to active components. When installation or service work is needed on a laser or laser system a qualified electrician shall be present. Contact the Facilities Department for assistance.

12.0 LASER GENERATED AIR CONTAMINANTS (LGAC)

Air contaminants may be generated when certain Class 3B and Class 4 laser beams interact with matter. These contaminants may be toxic, corrosive, or flammable gases, dusts, mists, or vapors. The LSO shall ensure that the industrial hygiene aspects of exposure to LGAC are addressed and that appropriate control measures are affected. Engineering controls shall be used to eliminate the hazards caused from LGAC. Other control measures include the use of respiratory protective equipment and isolation of the system.

13.0 OTHER NON-BEAM HAZARDS

Other hazards to be considered with the use of lasers and laser systems include the use of cryogenic gases as coolants, the use of compressed gases, the toxicity and

reactivity of the target material, noise levels generated, and arc of the filament lamps. Controls to mitigate these hazards shall be reviewed by the appropriate EHS personnel.

14.0 SURVEYS AND INSPECTIONS

Surveys and inspections shall be conducted annually and may coincide with the review and approval of SOPs by the NHMFL LSO. Additional inspections shall be performed randomly. Audit findings shall be addressed by the NHMFL Safety Office, PI or LLSO as required.

15.0 EMERGENCY RESPONSE PROCEDURES

If the injury is serious, call 911 for an ambulance. Describe the injury and arrange to meet the emergency personnel. Notify the NHMFL Safety Office at 855-SAFEMAG (723-3624).

Report all incidents involving exposure or suspected exposure to laser radiation to the NHMFL Safety Office at 855-SAFEMAG.

5.0 REFERENCES

5.1 Florida State University Laser Safety Manual
5.2 American National Standard for Safe Use of Lasers; ANSI Z136.1, most recent version
5.3 American National Standard for Safe Use of Lasers in Research, Development and Testing, Z136.8 most recent version

Appendix 1.

Temporary Work Authorization

Work as described below may be performed during the stated period after all required concurrences and authorizations have been obtained.

Effective date: **Expiration Date**:

Building: Room:

Maximum duration: two weeks

Work Scope (describe work including permitted and prohibited activities, boundaries and "stop points" as appropriate):

Controls required:

Personnel included in this authorization (signature denotes verification that training in the provisions of this Temporary Work Authorization has been provided)

Work Leader _____

Name Signature Date

(Work Leader is responsible for assuring that all required training, including job- and task-specific training, is provided prior to beginning work)

_____

Name Signature Date

_____

Name Signature Date

_____

Name Signature Date

_____

Name Signature Date

Concurrences and Work Authorization

Principal Investigator Concurrence _____

Name Signature Date

LLSO Concurrence _____

Name Signature Date

LSO Concurrence _____

Name Signature Date

Revisions

Date	Revision #	Section	Description
10/02/09	1	3.0	Update laser classifications.
10/02/09	1	Thru out	Update laser classification
10/02/09	1	Thu out	Document was reorganized to improve readability
03/25/13	2	3.1	Baseline exam/image for personnel working with class 4 lasers
03/25/13	2	9.6	Rewording for clarity
03/25/13	2	6.0	Refresher training changed from 3 years to 2 years
03/25/13	2	3.4	Meeting frequency changed from annually to semiannually
7/25/13	3	3.0	Update to laser classifications
7/25/13	3	Thru out	Reevaluate or remove sections that are not necessary for this procedure
7/25/13	3	Thru out	Update contact information
8/22/18	4	Front	Updated titles and names